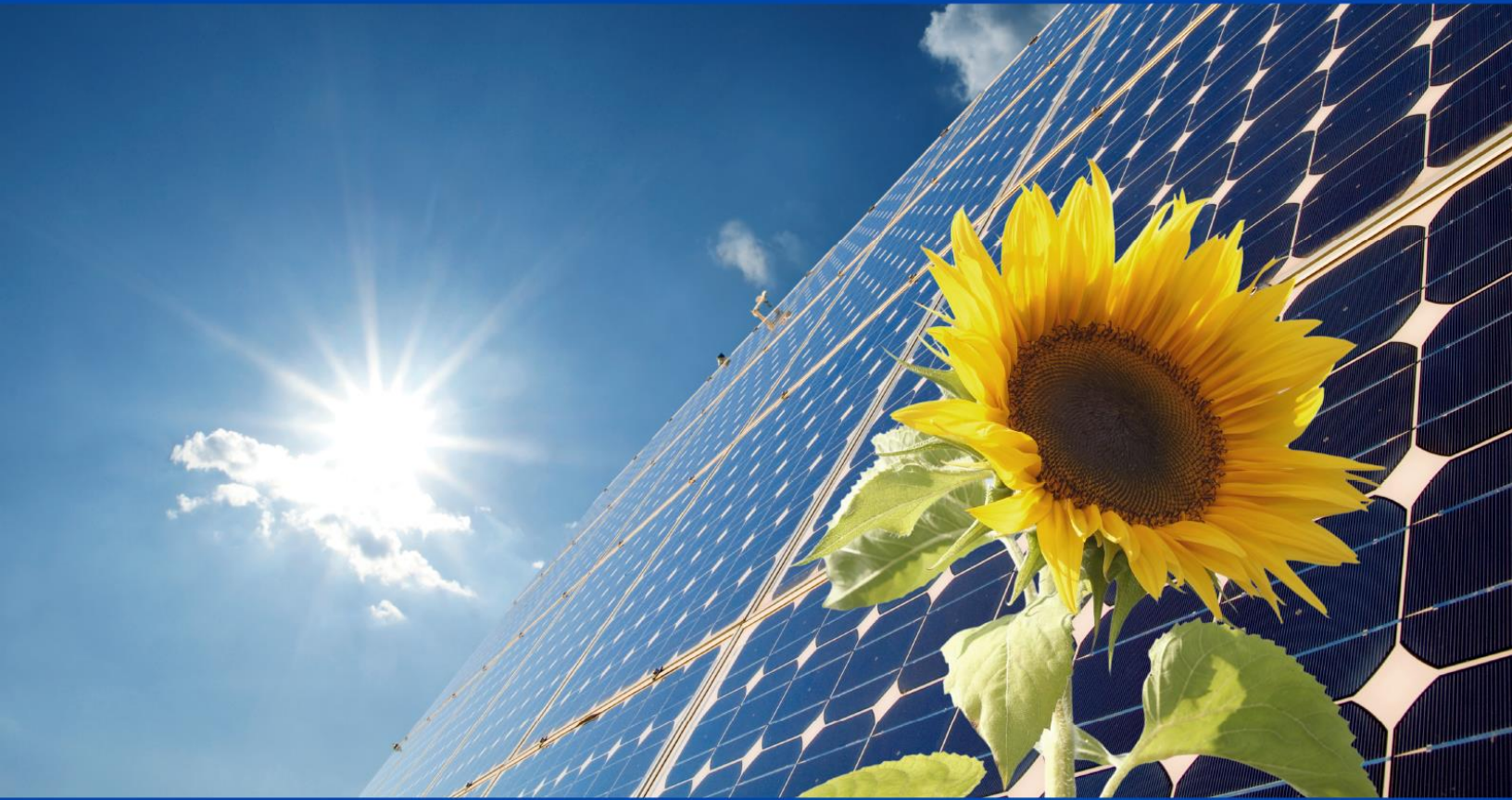




Seattle City Light



GUIDE TO INSTALLING A SOLAR ELECTRIC SYSTEM

Customer Energy Solutions

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seattle.gov/light/solar





Photo Credit: Seattle City Light

This guide is designed to provide Seattle City Light customers with information on grid-connected solar electric systems. It provides a background on solar electric systems and it outlines the steps to take to install a solar array at your home or business.

For solar questions not answered by this guide, please contact a Seattle City Light Energy Advisor at (206) 684-3800 or by email at SCLEnergyAdvisor@seattle.gov

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Introduction

More and more City Light customers are installing solar electric systems at their homes and businesses. If you are interested in producing your own electricity and want to reduce your personal environmental impact, now may be the time to learn more about installing a solar electric system.



Photo Credit: A&R Solar

- Solar electric systems are safe, reliable, pollution free, and use a renewable source of energy—the sun. Most systems have no moving parts and are increasingly easy to install.
- The option of net metering, or interconnecting a customer generating system to the utility grid, makes solar electric systems more economically viable.
- Federal and state financial incentives are available for owning and operating a solar electric system.

The History of Photovoltaic (PV) Technology

The first solar cell was created in 1883. It was inefficient by today's standards, converting only 1–2% of sunlight into electricity. The breakthrough in solar cell technology came in 1954 when researchers at Bell Laboratories stumbled across the photovoltaic (or PV) properties of silicon while experimenting with new technologies. Three years later, PV research began in earnest to develop an independent solar energy source for space technologies. Thanks



Photo Credit: Seattle City Light

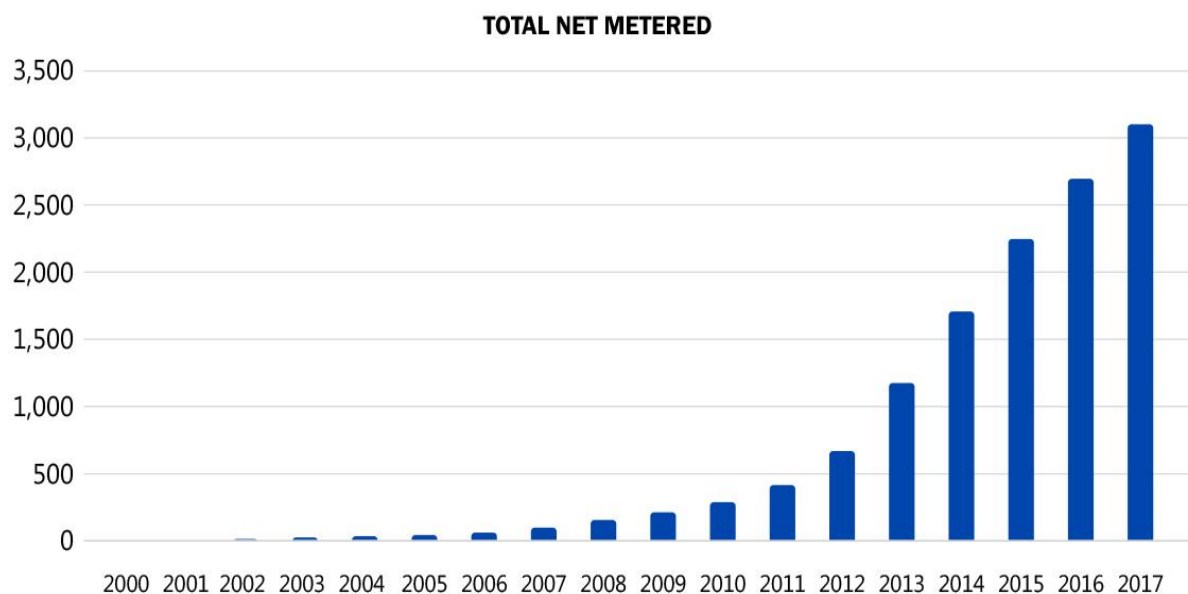
to continuing research, modern commercial PV silicon cells have improved to 15 –22% efficiency.

Historically, PV was extensively used in areas not served by a power grid. As PV prices have dropped, PV systems are increasingly used in grid-tied applications.

A solar electric or PV cell uses a semiconductor material, like that used in computer chips, to absorb sunlight and convert it into electricity. Multiple solar cells are linked together to form a module or panel. Multiple modules/panels are connected to form a PV array.

Seattle City Light has worked with customers to interconnect their solar electric systems since the first installation in 2001. Currently, there are over 3200 solar customers throughout City Light's service territory:

Solar Growth in Seattle

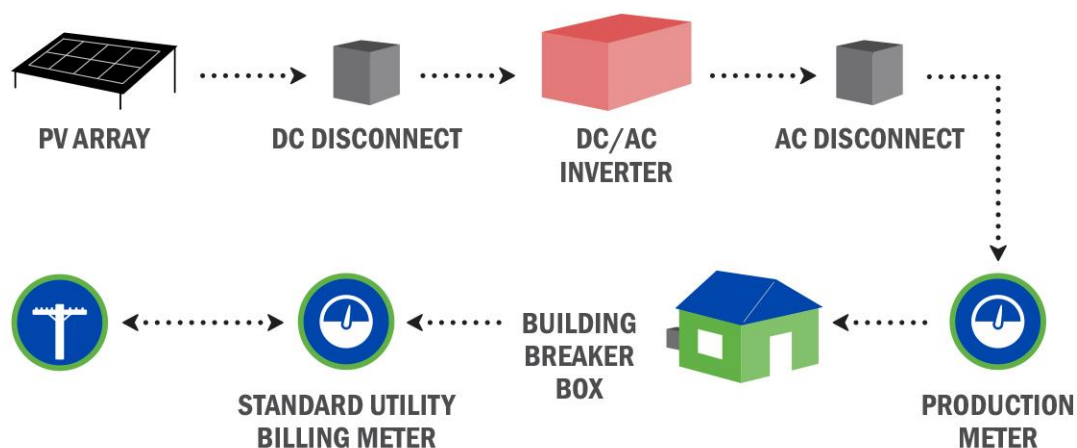


Solar growth in the Seattle City Light Service Area



- Solar Installations
- Seattle City Light Service Area

The Components of a Grid-Tied PV System



A PV System includes:

- 1) **PV Array** - Multiple PV panels installed together are called a PV array. Mounting arrays to rooftops is most common, yet they can also be located elsewhere like on a ground-mounted rack. The PV array produces Direct Current (DC) power.
- 2) **DC Disconnect** - The DC Disconnect is a safety device that, when manually opened, stops power running from the array to the rest of the system. The DC disconnect is used during system installation and anytime your contractor needs to work on the system.
- 3) **DC/AC Inverter** - The PV array produces DC electricity; however, we use Alternating Current (AC) electricity in our buildings and power grid. The Inverter converts the DC power to AC power. Inverters can serve an entire PV array or a single PV panel (called a "micro-inverter").
- 4) **AC Disconnect** - The AC Disconnect is another safety device and is often incorporated into the inverter. Seattle City Light does not require an AC Disconnect on systems under 10kW(ac), unless located in network areas. For details on this requirement, see the Seattle City Light "*Requirements for Electric Service Connection*" (Chapter 14: Customer Generation)
- 5) **Production Meter** - The Production Meter measures the energy output (in kilowatt-hours, kWh) from your system and is used to record the amount of electricity generated. This component is not critical to power generation, but is necessary to take advantage of Washington State's Production Incentive Program.
- 6) **Building Circuit Breaker Panel and Standard Utility Meter** - Also called your building's breaker box or electrical service panel, the circuit breaker panel is

where the power from the PV system enters the building. If the building is using electricity, the PV-produced electricity will be used first. If the building needs more electricity than the PV System is producing, utility grid power is automatically directed into the building. When the PV system produces more electricity than is needed, the excess power flows back out to the utility grid. You earn kWh credit for the excess power produced and can use that credit when the system is not producing enough electricity to meet the consumption needs in the building. This process is referred to as "net metering." Net metering is a billing program, see the Costs and Incentives section for more information about net metering.

Siting Your System

A well-designed solar electric system has clear and unobstructed access to the sun for most of the day throughout the year. Siting a PV system correctly is critical to achieve maximum power production.



Photo Credit: Sun Wind Concepts

Orientation and Tilt

Optimal orientation for solar panels is true south. As you move away from true south, a system will see production losses, up to as much as 15–25% for panels oriented east or west. However, with advancements in technology, these losses are decreasing as inverter manufacturers learn how to maximize off-of-south orientations. In Seattle, solar panels produce the maximum power annually when mounted at a south-facing tilt of roughly 30 degrees.

Shading

Avoid shading as much as possible. Even minimal shading can significantly impact power production. You will want to consider potential shading from trees, buildings, power lines, telephone poles, and obstructions like chimneys and vent pipes. Your contractor should include the impact of obstructions on your power production estimate. Your site should also factor in your neighbors potential building plans. Washington currently limits solar access rules to home owners' associations. Before installing solar, customers should research whether future building could affect the shading of their array.

Sloped Roof

A significant portion of your system cost will be in the installation of the panels, so if you plan on replacing your roof in the next 5–7 years, consider doing that first. Overall, you want to be sure your roof is in excellent long-term condition, because PV systems are designed to last a minimum of 20 years and many will last even longer. If you are unsure about the structural integrity of your roof, have it professionally inspected to verify its condition and suitability.

Flat Roof

Most residential and small commercial PV systems are installed on sloped roofs, yet it is possible to install on a flat roof. Contractors typically avoid penetrating a flat roof and instead use some sort of ballasted (weighted) means of securing the panels against wind. Building code officials will be concerned about the wind shear and roof loading of such a system. A flat roof might be easier and safer to walk on, but that does not equate to a simpler solar installation.

Tracking

Most residential and commercial PV installations are mounted to roofs and are fixed in place. If your system is going to be mounted on a pole or a flat roof, you have the choice of installing a tracking device. The simplest form of tracking is to seasonally adjust the tilt angle of the panels. Automatic tracking devices allow the panels to follow the sun as it moves through the sky, receiving direct light more often than a fixed system. Electrically operated and thermally operated trackers have their own costs, benefits, and drawbacks. Keep in mind that without a tracker, your PV system has no moving parts. While automatic trackers can increase production by 20–40%, they do add moving parts to the system, so consider operation and maintenance concerns. Pole-mounted systems also have the additional cost of the pole installation.

Learn more about the solar potential at your home by using the National Renewable Energy Laboratory's (NREL) PV WATTS calculator: pwwatts.nrel.gov or google.com/get/sunroof

Selecting the Right Size System

Three core factors affect the sizing of your system: your electricity usage, space availability on your property, and your budget.

Your Electricity Usage

Do you want to try to produce 100% of your power or some smaller percentage?



While any excess production from month to month will carry over as a kWh credit on your utility bill (net metering), you will not want to install a system that produces more than 100% of your power needs annually as the utility will not reimburse you for excess power produced at the end of the year.¹ We encourage you to perform all energy-efficiency upgrades before sizing your system or consider any future energy conservation upgrades. You want to avoid oversizing the PV system.

To determine how much power you use right now, look for the kilowatt-hour (kWh) consumption on your utility bill. Sum the kWh for the past year to get your annual electricity usage. For help understanding your bill, check out seattle.gov/light/paymybill.

1 kW of solar typically produces 1000 kWh annually. Remember, the seasonal output varies in our region. 1 kW of solar radiation might produce only 20 kWh in December but will be closer to 160 kWh in July. Here are some other considerations for sizing a solar system:

- Annual usage for a typical Seattle home: See 2016 annual Report: seattle.gov/light/pubs/annualrpt/2016/flipbook/index.html?page=88
- The typical electric vehicle uses approximately 3000 kWh annually. The average solar system size was approximately 7 kW in 2017
- The average cost of solar is about \$3400 per kW before incentives or taxes

¹ The year is defined as May 1st through April 30th by state law.

Space Availability

1 kW of solar typically requires about 80 square feet of roof space. PV Watts (pvwatts.nrel.gov) from NREL can help map your roof or use Google's Project Sunroof at: google.com/get/sunroof#p=0.

General Rule:

1 kilowatt (kW) of PV panels will require approximately 80 square feet of area. If PV panels are unshaded, oriented to true south and mounted at approximately 30 degrees, they will produce approximately 1,000 kilowatt-hours (kWh) per year in Seattle.

Tree Removal

Please consider reviewing the City of Seattle's policies on tree removal if you have significant shading from trees on your property:

seattle.gov/dpd/codesrules/codes/treeprotection

Permits for solar energy systems do not consider adjacent trees or give property owners special permission to remove trees that could interfere with their system. [Tip 242, Tree Protection Regulations in Seattle](#), summarizes tree regulations for private property.

Tip 242: <http://www.seattle.gov/DPD/Publications/CAM/cam242.pdf>

Panel Selection

PV panels vary in dimensions. Local contractors may have brands they install regularly. Consult with an installer for the pros and cons of the various module sizes, the type of panels they use and why they like them, the panels' UL listing (required for electrical inspection and utility interconnection) and the panels' warranty. A standard industry PV panel warranty is 20–25 years, and manufacturers expect the panel will produce 80% of its rated capacity at the end of the warranty period.

Budget

It is a good idea to evaluate your budget and goals before choosing your system. Some questions to consider include: What is my budget for this project? Will I finance or pay for it out of my savings? Keep your budget in mind as you read the Cost and Incentives section of this guide.

Additionally, you may want to consider contacting lenders to help you finance your solar project. Many services are available, and some can load the loan payment on your City Light bill.

Permit Requirements

Electrical Permit

Electrical permits are required for all solar electric systems and must be secured by the person doing the electrical work. In most of cases this will be your electrical contractor. Owners with the required planning and installation skills, who want to complete the installation themselves, can



Photo Credit: Sunergy

also obtain the electrical permit. Your contractor must submit an electrical drawing (one-line diagram) and the system will be subject to a field inspection after installation. If your system has a larger capacity than 7 kW or the design is atypical, your contractor may be required to go through a plan review.

Building Permit

Building permits in Seattle are required for solar arrays when any of the following apply:

- 1) The array weight is 1,000 pounds or more.²
- 2) The installation is structurally complex (determined by the Seattle Department of Construction and Inspections).
- 3) The solar project is part of building alterations or additions valued over \$4,000.
- 4) The solar project requires construction of stand-alone support structures valued over \$4,000

General Rule:

As a point of reference, a 2 kW PV system will weigh approximately 500 pounds.

Resource:

For Seattle residents, permits may be obtained at the Seattle Department of Construction and Inspections,

700 Fifth Avenue, 20th floor, (206) 684-8850, or at seattle.gov/dpd/permits.

For electrical permit questions, contact SDCI's Electrical Technical Support at (206) 684-5383.

² Building permits may be required if your system will be installed on a flat roof. In such an installation, specific calculations regarding roof loading and wind shear are required.

Land Use Requirements

In single family, multi-family and residential small lot zones, solar panels may be mounted to extend up to four feet above the zone's height limit, and/or extend up to four feet above the ridge of a pitched roof. Also, the total height from existing grade to the top of the solar panels may not extend more than nine feet above the zone's height limit.

In single family and residential small lot zones, a solar panel exceeding the zone height limit must be placed so that it does not excessively shade the property to the north per TIP 417: Sun chart: Determination of Solar Exposure that can be viewed here:

seattle.gov/DPD/Publications/CAM/cam417.pdf

Set-Back Requirements

Ground or pole-mounted PV systems cannot be in front yards. They must be at least 15 feet from back property line and three feet from side property line. More specifics on set-back requirements can be found in TIP 420: Solar Energy Systems. All TIPS can be viewed on the City of Seattle DCI website here:

web6.seattle.gov/DPD/CAMS/camlist.aspx.

Costs and Incentives

Typical System Cost

Cost depends on several factors (e.g. roof complexity). Typical residential systems in Seattle are approximately 7 kilowatts (kW) in size with an average installed cost of \$3,400 per kW for a total investment of \$25,000.



Photo Credit: Western Washington Solar

Net Metering

Net metering allows solar customers to send excess electricity generated back to the grid. If you generate more electricity over a billing period than you consume, City Light will credit your electric bill for every kilowatt-hour of electricity sent back to the power grid. The kWh credit is tracked in your City Light billing account for use later in the year when buildings typically utilize more grid energy than solar energy. kWh credits can roll forward each billing period until the end of the net metering year on April 30th each year. On April 30th, net metering credits are reset to zero.

Federal Income Tax Credits

The federal Energy Policy Act of 2005, as amended by the Emergency Economic Stabilization Act of 2008, includes provisions for individuals and businesses to claim a 30% federal income tax credit for the cost of solar installations through December 31, 2021. A great resource for information on Federal Tax Credits, visit: dsireusa.org.

Washington Renewable Energy Production Incentive

Washington State provides financial incentives for electricity generated from renewable energy resources. Eligible electricity producing renewables include solar, wind, and anaerobic digesters (converts methane gas captured from livestock manure to electricity). The state production incentive program is administered by City Light and the Washington State University Energy Program (WSUEP) on behalf of the state.

The state's annual incentive is calculated on the total number of kilowatt-hours (kWh) of electricity generated from July 1st to June 30th each year. Customers with eligible generation systems that have been certified by WSUEP and have met City Light incentive eligibility requirements, may receive an annual incentive payment.

The chart below contains production-based solar incentive rates per kWh for new systems certified after September 30, 2017. City Light reports annual production of your system to the WSU Energy Program. WSU calculates your incentive for the fiscal year and shares this information with City Light, who issues incentive payments by December 15 of that fiscal year.

FISCAL YEAR OF SYSTEM CERTIFICATION	BASE RATE RESIDENTIAL-SCALE	BASE RATE COMMERCIAL-SCALE	BASE RATE COMMUNITY SOLAR	BASE RATE SHARED COMMERCIAL SOLAR	MADE IN WASHINGTON BONUS
2018	\$0.16	\$0.06	\$0.16	\$0.06	\$0.05
2019	\$0.14	\$0.04	\$0.14	\$0.04	\$0.04
2020	\$0.12	\$0.02	\$0.12	\$0.02	\$0.03
2021	\$0.10	\$0.02	\$0.10	\$0.02	\$0.02

Certification of a new system may take up to 30 days from date of submission. WSU encourages applicants to submit their application when the renewable energy system passes final electrical inspection.

To register a new solar system, the Washington State University Energy Program can be reached at: energy.wsu.edu/RenewableEnergySystemIncentiveProgram.aspx

New customers should anticipate payments for eight years. The program will be closed to new participants when incentives for City Light, or the state, reaches the program funding limit per WAC 458-20-273: apps.leg.wa.gov/WAC/default.aspx?cite=458-20-273

Legacy Solar Customers (Installed 2005-2017)

Per state law, all legacy customers will be paid at the 2015-2016 incentive rate for payment years 2018 to 2020.

Customer Generation	Payment Rate
Both solar modules and inverters manufactured in Washington state.	\$0.3915/kWh
Solar modules manufactured in Washington state.	\$0.261/kWh
Solar with an inverter manufactured in Washington state.	\$0.1305/kWh
Solar equipment manufactured outside of Washington state.	\$0.10875/kWh
Community Solar	\$0.783/kWh

Maintenance & Resale

Regular Maintenance

Very little maintenance is required on a PV system with no moving parts. Some system owners wash their panels, but in the Northwest, our climate tends to take care of this through precipitation. You may want to brush off the panels if they tend to collect leaves, but other than that, your system



Photo Credit: Seattle City Light

should operate as designed with no intervention. You can also keep track of your production by reading your production meter, checking the inverter display, or watching your production reads on your billing statement.

Inverters have a shorter life span than solar panels and are rated for about ten years. The system should be monitored occasionally to ensure the inverter(s) function properly.

Resale Value

The effect of a solar system on the appraised value of your home can be hard to predict, but evidence suggests that it adds value to the home. A 2015 study from the Lawrence Berkley Laboratory shows resale premiums of about \$4 per watt, or about \$15,000 for a typical PV system: newscenter.lbl.gov/2015/01/13/berkeley-lab-illuminates-price-premiums-u-s-solar-home-sales

Choosing an Installer

As with any construction project, best practices include asking these basic questions of a potential contractor:

- Do they have a business license?
- Are they licensed for the work you want them to do (mechanical, electrical, structural, etc.)?
- How long have they been in business?
- How many solar electric systems have they installed?
- Will they provide references?
- Have they attended manufacturer, trade association, or other training on solar electric installations?



Photo Credit: Puget Sound Solar

In comparing bids, you should consider warranty service, installed system price (equipment plus installation), system size, permit costs, and predicted energy output.

The Solar Installers of Washington hosts a membership roster with names of local installers near you: solarinstallersofwa.org/membership.html

The North American Board of Certified Energy Practitioners (NABCEP) runs a quality credentialing and certification program for renewable energy professionals. To be NABCEP certified, a practitioner must meet installation experience requirements, sign a code of ethics and pass a four-hour exam. Look for the NABCEP seal on contractors' websites. More information about NABCEP and a list of certified installers can be found at their web site: nabcep.org

Installation and Incentive Checklist: 9 Steps to Solar Power

1) System Selection

Contact installers, schedule site evaluations, and choose your system design. Use the “Find Solar Installers” link at seattle.gov/light/solar or look at the membership list at Solar Installers of Washington: solarinstallersofwa.org/membership.html

2) Interconnection Application

The following interconnection application documents are required (most solar installers will provide these for you):

- Interconnection Application & Agreement – Level 1 (for inverter-based generating systems – 100 kW or less)
- “One-line” electrical diagram of the proposed generating system
- Application for Electric Service — required for production meter service and to participate in the WA state production incentive program. This is available online at: seattle.gov/light/electricservice

Complete and submit these forms prior to installation along with the production meter installation fee. City Light Electric Service Representatives (ESRs) are available to work with you or your installer to review your application submittals and to advise you regarding meter installations and fees. The application will be reviewed, and the Interconnection Agreement will be kept on file at City Light.

Systems larger than 10kW (AC) or with battery backup will require engineering review. Systems located in the Downtown, First Hill, or University District network areas will require engineering review and protective equipment. This may add time, expense, and complexity to the installation.

Your ESR may visit your site prior to installation to mark the appropriate location for a production meter socket (socket to be installed by your installer; meter to be installed by City Light).

Submit Interconnection Applications to:

Seattle City Light
Attn: Intake Desk
1300 N. 97th St
Seattle WA, 98103
(206) 233-2777

3) Electrical Permit

The person installing the system, typically your solar contractor, must obtain an electrical permit. Zoning, setback requirements, roof height, and exposure may impact your installation. Contact their Local Jurisdictional Authority (LJA) for land-use and electrical permit information if you have questions about your property.

4) Installation

Install your solar electric system, including your production meter socket. City Light may have marked the ideal location for the production meter socket (for ease of meter reading). If you or your contractor have any questions about the marked location, please call your Electrical Service Representative (ESR). Meter bases should be labeled in accordance with City Light signage requirements as detailed in the *Seattle City Light Requirements for Electrical Service Connections* (Chapter 14: Customer Generation).

5) Electrical Inspection

Once installation is complete, call the Seattle Department of Construction and Inspections (or your local electrical permitting office if you are outside of Seattle) for an electrical inspection. New construction requires both a cover and final inspection—existing structures require only a final inspection.

After passing the electrical inspection, you must notify your ESR, who you can locate on via our service maps located at: seattle.gov/light/electricservice or by contacting the appropriate service center.

6) Metering

Once City Light confirms your system was installed according to plan and has passed inspection, your billing meter will be configured to receive net power data, and your production meter will be installed. A production meter is only required if you plan to apply for production incentives. If you are not planning to apply for production incentives, this is your last step.

7) Washington State System Certification

To be eligible for state production incentives, you must complete the WSU Energy Program certification application. You should apply to WSU with the name as it appears on your Seattle City Light billing statement. WSU's application can be found at: energy.wsu.edu/RenewableEnergySystemIncentiveProgram.aspx

8) Apply for Federal Tax Credits

Individuals and businesses that install solar electric systems are eligible for a federal tax credit of 30% of the system cost (the total of installation and materials), until 12/31/19. After 2019, the tax credit declines annually. Individuals use Residential Energy Credits IRS Form 5695 and businesses use the Investment Credit IRS Form 3468.

Updated forms can be found on the IRS website: [irs.gov](https://www.irs.gov).

9) Annual Incentive Payments

To monitor your production and calculate your incentive, City Light will read your production meter on the same schedule as your existing billing meter.

The annual incentive application process will be run through WSU Energy Program. City Light will provide production meter reads to the WSU Energy Program, who will in return supply a payment amount to City Light for payment in the fall.

First time incentive payment applications must ensure all City Light eligibility requirements are met. Eligibility requirements can be located online at: seattle.gov/light/solarenergy/incentiveRequirement.asp.

As a renewable energy generator, you must maintain all records of energy production and incentive payments received for a period of five years.

Solar Access

At this time, there are only solar access laws surrounding how home owners' associations can treat solar. There are no current solar access rules for trees growing on a neighbor's property or if the neighbor decides to build to the limit of their building height.

Batteries and back-up generators

Batteries and back-up generators add complexity to a solar performance-based incentive. If you are considering battery backup or backup generators, please inform a City Light Electric Service Representative (ESR) at the beginning of the project. Seattle City Light does not currently offer incentives for batteries or back-up generators.

Additional Resources

For solar questions not answered by this guide please contact a Seattle City Light Energy Advisor at (206) 684-3800 or by email at SCLEnergyAdvisor@seattle.gov

For questions directly related to annual incentive payments or billing questions, please contact the City Light Solar Incentive Group at (206) 684-5516 or SCL_SolarInentive@seattle.gov



Photo Credit: Martha Rose

If you want to do additional research, here are some resources you may find useful:

- U.S. Department of Energy Solar Energy Technologies Program—a consumer resource covering solar basics, applications, and, research and development at the national level: energy.gov/eere/solarpoweringamerica/solar-powering-america-home
- Solar Washington—the local chapter of the American Solar Energy Society, providing events and newsletters: solarwashington.org

Solar Works in Seattle!

We hope you decide to join the many Seattle area residents who are taking advantage of a local renewable resource to generate their own clean, green power.

Seattle City Light is a publicly owned utility dedicated to exceeding our customers' expectations in producing and delivering low cost, reliable power in an environmentally responsible and safe way. We are committed to delivering the best customer service experience of any utility in the nation.